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ROLE OF COMPUTED TOMOGRAPHY IN ASSESSING PARANASAL SINUS DISEASE: CORRELATION WITH CLINICAL FINDING AND ANATOMICAL VARIATIONS

Original Research

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ABSTRACT

Background: Paranasal sinus diseases are frequently underdiagnosed or misdiagnosed due to overlapping clinical presentations. Anatomical variations in the sinonasal region significantly contribute to disease onset and persistence. Accurate imaging is essential to distinguish between inflammatory processes and structural abnormalities. Computed tomography (CT) offers high-resolution, multiplanar visualization of sinonasal anatomy, making it the preferred modality for diagnosing paranasal sinus pathologies and planning appropriate treatment strategies.

Objective: To analyze the role of computed tomography in assessing paranasal sinus diseases and its correlation with clinical findings and anatomical variations.

Methods: This cross-sectional study was conducted over three months at Tehsil Headquarters (THQ) Hospital, Sadiqabad. A total of 60 patients aged 18–60 years of both genders were enrolled using a non-probability convenient sampling technique. Patients with recent sinus surgery, facial trauma, or pregnancy were excluded. All participants underwent paranasal sinus CT scans using a Toshiba Canon Aquilion 16-slice machine. Data on clinical symptoms, anatomical variations, and radiological findings were collected and analyzed. Chi-square tests were used to evaluate associations between anatomical structures and sinus pathology.

Results: Among the 60 patients, sinusitis was identified in 38.3% (n=23), nasal polyps in 31.7% (n=19), mucosal thickening in 11.7% (n=7), and chronic sinusitis in 10.0% (n=6). Only 6.7% (n=4) showed normal CT findings. Deviated nasal septum was the most common anatomical variation (35.0%), followed by bone remodeling (26.7%) and agger nasi cells (20.0%). A statistically significant correlation was found between anatomical variations and paranasal sinus disease ($p = 0.000$).

Conclusion: Computed tomography is an essential diagnostic modality for paranasal sinus diseases, offering precise visualization of anatomical variations. Its use significantly enhances diagnostic accuracy and guides effective treatment planning.

Keywords: Agger Nasi Cells, Anatomical Variation, Computed Tomography, Paranasal Sinuses, Radiology, Sinusitis, Structural Abnormalities.

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INTRODUCTION

Paranasal sinus diseases encompass a wide spectrum of conditions ranging from inflammatory disorders such as sinusitis to various neoplastic growths, both benign and malignant. These air-filled cavities—maxillary, frontal, ethmoid, and sphenoid sinuses—are intricately associated with the anatomy of the skull base and are in close proximity to vital neurovascular structures, making accurate diagnosis crucial for effective management (1,2). The nasal cavity and paranasal sinuses function as a unified respiratory unit, performing essential roles in air filtration, humidification, voice resonance, and immune defense. They also contribute significantly to craniofacial development and individual facial morphology, with their size and configuration varying widely among individuals due to genetic and developmental factors (3-7). During early fetal development, these structures begin to form as outpouchings from the nasal cavity, with full maturation continuing into adulthood. Maxillary sinuses are the first to develop, achieving full growth between the ages of 20 and 30, whereas the frontal and sphenoid sinuses mature later in life. The ethmoid sinuses, although present at birth, complete their development by adolescence. The growth and pneumatization of these sinuses are influenced not only by genetic predisposition but also by infections, dentition, and age (8-10).

Traditionally, plain radiography has been utilized to evaluate sinus pathology, especially in the maxillary and frontal regions. However, it offers limited visualization of anterior ethmoidal cells, the frontal recess, and the upper nasal cavity, reducing its diagnostic accuracy in complex or posterior sinus involvement (11). In contrast, computed tomography (CT) has emerged as the gold standard for evaluating paranasal sinus diseases. Its ability to capture high-resolution, multiplanar images enables detailed assessment of mucosal pathology, bone erosion, anatomical variations, and extent of disease—key elements in both diagnosis and surgical planning (12). CT imaging plays a pivotal role in distinguishing between acute and chronic sinusitis based on mucosal thickening, sinus opacification, and the presence of air-fluid levels, all of which are essential for accurate therapeutic decisions (13). Beyond inflammation, CT effectively identifies anatomical variants such as concha bullosa, paradoxical middle turbinates, and septal deviations—factors that often contribute to recurrent or refractory sinus disease (12). It also provides critical insights into sinonasal trauma, congenital anomalies like aplasia or hypoplasia, and invasive fungal sinusitis characterized by hyperdense calcifications not typically seen in bacterial infections (4,5).

Furthermore, in the context of neoplastic processes, CT helps differentiate benign tumors such as osteomas and inverted papillomas from malignant lesions including squamous cell carcinoma and adenoid cystic carcinoma. Evaluating bone erosion, soft-tissue extension, and contrast enhancement patterns assists clinicians in distinguishing tumor infiltration from inflammation, thus guiding biopsy and treatment strategies (6,9). For chronic rhinosinusitis, CT scoring systems like the Lund-Mackay score facilitate objective disease grading and postoperative outcome prediction (11). In surgical settings, CT imaging has become indispensable for functional endoscopic sinus surgery (FESS). Image-guided surgical navigation systems rely heavily on preoperative CT scans to minimize complications by enhancing precision in anatomically crowded areas such as the orbit and skull base (14). Despite these advancements, limited research has addressed the direct correlation between CT findings, clinical symptoms, and anatomical variations, leaving a gap in evidence-based evaluation frameworks. Therefore, this study aims to analyze the role of computed tomography in assessing paranasal sinus disease and its correlation with clinical findings and anatomical variations.

METHODS

This cross-sectional study was carried out over a period of three months at Tehsil Headquarters (THQ) Hospital, Sadiqabad. A total of 60 patients aged between 18 and 60 years, of both genders, were included using a non-probability convenient sampling technique. The inclusion criteria comprised patients presenting with common sinonasal symptoms, while individuals with a recent history of sinus surgery, facial trauma, or pregnancy were excluded to eliminate confounding factors (15,16). All participants underwent computed tomography (CT) scans of the paranasal sinuses using a Toshiba Canon Aquilion 16-slice scanner. CT imaging was performed in both axial and coronal planes with thin-section acquisition for optimal visualization of bony structures and soft tissue abnormalities. The imaging findings were interpreted by experienced radiologists following standardized radiological protocols. Data were entered and processed using SPSS version 23.0. Descriptive statistics were used to summarize demographic characteristics and CT findings. Inferential statistical analysis was conducted using Pearson’s Chi-square test to evaluate the association between anatomical variations,

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sinus involvement, and paranasal sinus pathology. A p-value of less than 0.05 was considered statistically significant. All participants provided informed written consent prior to enrollment, and ethical approval for the study was obtained from the relevant institutional review board (IRB).

RESULTS

A total of 60 patients were included in the study, with a male predominance of 61.7% (n=37) compared to 38.3% females (n=23). The frequency of paranasal sinus disease showed that sinusitis was the most common condition, observed in 38.3% (n=23) of patients, followed by nasal polyps in 31.7% (n=19), mucosal thickening in 11.7% (n=7), chronic sinusitis in 10.0% (n=6), and a combination of polyp with hemorrhage in 1.7% (n=1). Only 6.7% (n=4) of patients demonstrated normal paranasal sinus findings. Anatomical variations were frequently encountered, with deviated nasal septum (DNS) being the most prevalent in 35.0% (n=21) of cases. Bone remodeling and expansion were found in 26.7% (n=16), while agger nasi cells were present in 20.0% (n=12). Combined DNS with concha bullosa was identified in 8.3% (n=5) of patients, and isolated concha bullosa was observed in 1.7% (n=1). Normal anatomical configuration was seen in only 8.3% (n=5) of the cohort. Among the clinical findings, nasal blockage was the most commonly reported symptom, affecting 51.7% (n=31) of patients. Nasal polyps were present in 13.3% (n=8), nasal congestion in 8.3% (n=5), and nasal discharge, facial pain, and headache were each noted in 5.0% (n=3). Less frequent complaints included nasal obstruction and sinusitis (3.3% each), while chronic cough with congestion and polypoidal masses were seen in 1.7% (n=1) of cases.

Evaluation of sinus involvement revealed that the maxillary and ethmoid sinuses were the most commonly affected together, seen in 36.7% (n=22) of patients. Isolated maxillary sinus involvement was found in 15.0% (n=9), while frontal and ethmoid sinuses were involved in 8.3% (n=5). Frontal, sphenoid, and ethmoid involvement was recorded in 5.0% (n=3), and all sinuses were involved in another 5.0% (n=3). Only 6.7% (n=4) had no sinus involvement. Regarding the side of involvement, bilateral sinus disease was present in 70.0% (n=42) of patients, while unilateral disease was equally distributed on the right and left sides, each accounting for 13.3% (n=8). No side-specific involvement was found in 3.3% (n=2) of patients. Chi-square analysis indicated a statistically significant association between paranasal sinus diseases and anatomical variations ($p < 0.001$). Similarly, a significant correlation was observed between the types of sinuses involved and the type of disease diagnosed ($p = 0.000$), although a high number of cells had expected counts below five, which may limit the strength of the association.

Table 1: Frequency of male and female patients

	Frequency	Percent	Cumulative Percent
Female	23	38.3	38.3
Male	37	61.7	100
Total	**60**	**100**	

Table 2: Frequency of paranasal disease among patients

	Frequency	Percent	Cumulative Percent
Normal	4	6.7	6.7
Sinusitis	23	38.3	45
Nasal Polyp	19	31.7	76.7
Mucosal Thickening	7	11.7	88.3
Chronic Sinusitis	6	10	98.3
Polyp and Hemorrhage	1	1.7	100
Total	**60**	**100**	

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Table 3: Frequency of anatomical variations among patients

	Frequency	Percent	Cumulative Percent
Normal	5	8.3	8.3
Deviated nasal septum	21	35	43.3
Bone remodelling and expansion	16	26.7	70
Agger Nasi cells	12	20	90
Deviated nasal septum, Concha bullosa	5	8.3	98.3
Concha bullosa	1	1.7	100
Total	**60**	**100**	

Table 4: Clinical Findings among patients

	Frequency	Percent	Valid Percent
Nasal Blockage	31	51.7	51.7
Facial Pain	3	5	56.7
Nasal Congestion	5	8.3	65
Nasal Polyp	8	13.3	78.3
Nasal Obstruction	2	3.3	81.7
Sinusitis	2	3.3	85
Chronic cough and congestion	1	1.7	86.7
Nasal Discharge	3	5	91.7
Polypoidal mass	2	3.3	95
Headache	3	5	100
Total	**60**	**100**	

Table 5: Frequency of Sinus and Side Involvement in Patients with Paranasal Sinus Disease

Sinus Involvement	Frequency	Percent	Cumulative Percent	Side Involvement	Frequency	Percent	Cumulative Percent
None	4	6.7	6.7	None	2	3.3	3.3
All Sinuses	3	5.0	11.7	Bilateral	42	70.0	73.3
Frontal	3	5.0	16.7	Right	8	13.3	86.7
Maxillary	9	15.0	31.7	Left	8	13.3	100.0
Ethmoid	2	3.3	35.0				
Maxillary, Ethmoid	22	36.7	71.7				
Frontal and Ethmoid	5	8.3	80.0				
Frontal, Sphenoid, Ethmoid	3	5.0	85.0				
Total	60	100		Total	60	100	

Table 6: Chi Square test anatomical variations and PNS Disease

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	70.250a	25	0
Likelihood Ratio	50.384	25	0.002
N of Valid Cases	**60**		

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Table 7: Chi Square test Sinus involved

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	97.768a	45	0
Likelihood Ratio	64.684	45	0.029
N of Valid Cases	**60**		

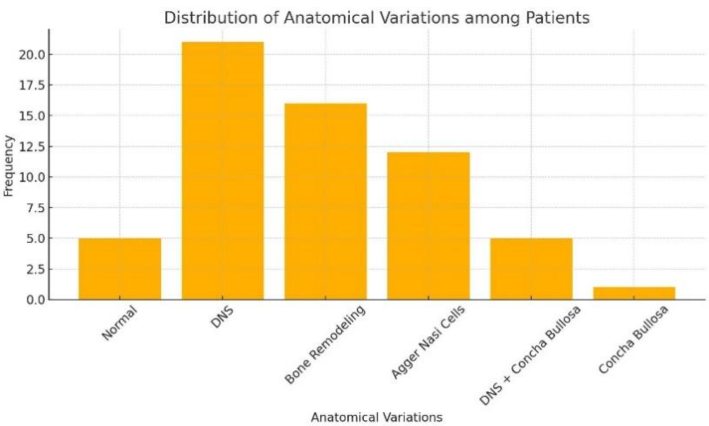


Figure 1 Distribution of Anatomical Variations among Patients

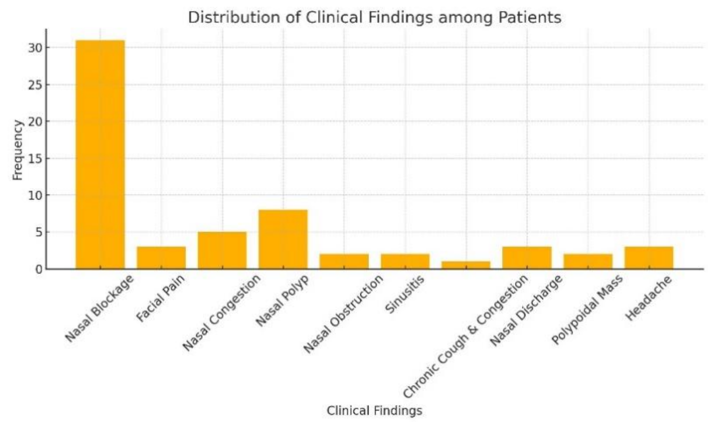
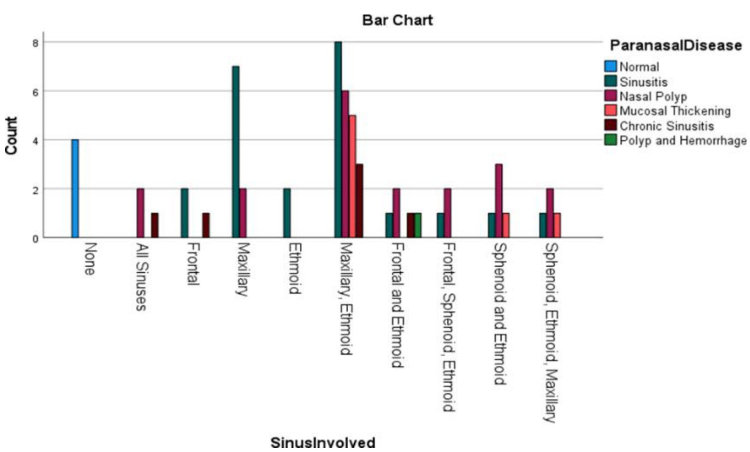
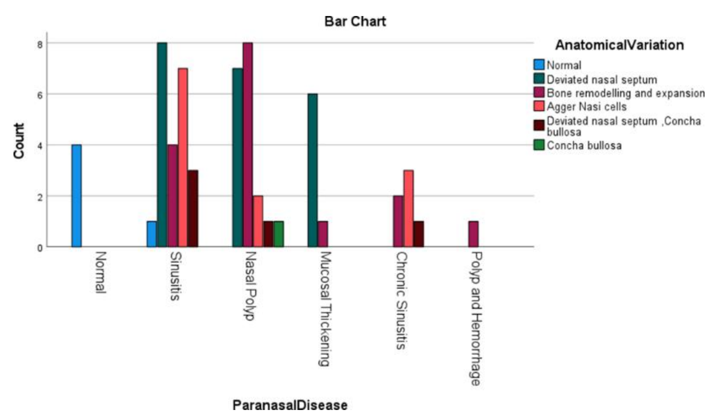


Figure 2 Distribution of Clinical Findings Among Patients





DISCUSSION

The findings of this study reinforce the understanding that anatomical variations within the sinonasal region significantly influence the development and presentation of paranasal sinus diseases. In a cohort of 60 patients undergoing CT evaluation for suspected sinus pathology, sinusitis was found to be the most prevalent condition, followed by nasal polyps, mucosal thickening, and chronic sinusitis. This disease distribution closely reflects earlier observations in similar populations where inflammatory and polypoidal changes dominate clinical presentations. The predominance of nasal blockage as a clinical symptom aligns with the radiological findings, emphasizing its strong association with sinusitis and polyp formation. A key anatomical variation observed in this study was the deviated nasal septum, affecting 35% of participants, a prevalence rate supported by regional studies but lower than international reports that have noted incidence rates exceeding 60%. The current incidence of concha bullosa at 8.3% was also lower than what has been reported in larger sample studies, which recorded frequencies ranging from 30% to nearly 50%. Such discrepancies could be attributed to

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variability in imaging modalities, sample sizes, demographic factors, and criteria used to define these variations (16,17). The presence of agger nasi cells in 20% of the sample was consistent with the range reported in comparable radiological surveys.

Statistical analysis revealed a significant correlation between anatomical variations and paranasal sinus diseases ($p = 0.002$), suggesting that deviations in sinonasal architecture play a contributory role in disease pathophysiology. The association between sinus involvement and disease type was also statistically significant ($p = 0.000$), confirming the relevance of CT imaging in mapping disease patterns. These findings are in line with previously published systematic reviews and clinical studies that have emphasized the importance of understanding sinonasal anatomy in the management of chronic rhinosinusitis (18,19). However, some studies have argued that anatomical abnormalities may not independently predispose individuals to sinus disease, highlighting the multifactorial nature of rhinosinusitis, where factors such as environmental allergens, microbial colonization, and immune response interplay (20,21). Interestingly, the study did not demonstrate a statistically significant relationship between clinical symptoms and radiological disease findings. This lack of correlation underscores the often-subjective nature of symptom reporting in sinus diseases and the potential discrepancy between symptom severity and radiological extent. It also highlights the value of CT imaging in clarifying ambiguous clinical presentations and guiding evidence-based management.

One of the strengths of this study lies in its use of computed tomography as the primary diagnostic modality, offering detailed anatomical visualization and the ability to detect subtle mucosal and bony changes. This enabled a more accurate assessment of disease patterns and anatomical anomalies. Furthermore, the inclusion of both genders across a broad adult age range enhances the representativeness of the sample. Nevertheless, certain limitations must be acknowledged. The study employed a convenient sampling method and included a relatively small sample size, which may have introduced selection bias and limited generalizability. Additionally, the absence of detailed correlation between individual clinical symptoms and specific CT findings reduces the strength of conclusions regarding clinical-radiological relationships. The analysis also did not stratify findings by age or comorbid conditions, factors that may have influenced both anatomical development and disease expression. The reliance on frequency-based analysis without adjusting for potential confounders restricts the depth of statistical interpretation. Future research should consider prospective multicenter designs with larger, randomized populations to validate these findings (22). Comparative analyses using advanced imaging modalities such as cone-beam CT or MRI could provide additional insight into soft tissue pathology. Integrating clinical symptom scores with radiological grading systems may also improve diagnostic accuracy and enhance the predictive value of CT imaging in sinus disease management. In conclusion, this study adds to the growing body of evidence highlighting the significant role of anatomical variations in paranasal sinus diseases. It emphasizes the indispensable role of CT imaging in diagnosis and treatment planning while also pointing toward the complexity of symptomatology and disease expression in sinonasal disorders.

CONCLUSION

Computed tomography proved to be a valuable diagnostic tool for evaluating paranasal sinus diseases, offering precise visualization of both pathological changes and anatomical variations. The study demonstrated a clear association between structural anomalies and sinus pathology, emphasizing the role of CT imaging not only in accurate diagnosis but also in guiding clinical decision-making. These findings support the integration of CT scanning into routine assessment protocols for patients presenting with sinonasal symptoms, ultimately contributing to more targeted and effective management strategies.

AUTHOR CONTRIBUTION

Author	Contribution
Aiman Batool*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Kiran Muhammad baksh	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Hafza Sadiq	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Muqadas Maryam	Contributed to Data Collection and Analysis

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Author	Contribution
	Has given Final Approval of the version to be published
Fozia Amin	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Maryam Sohail	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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